Electron/Photon Related Projects

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Disclaimer / Introduction

- PRS EGamma split into DPG and POG
  - DPG – detector performace, service tasks: amplitude reconstruction, selective readout, DQM, calibartion, databases, etc, etc. (Meridiani & Seez)

http://indico.cern.ch/conferenceDisplay.py?confId=11932

  - POG – electron/photon ID, energy scales, etc. Does not count as service work… (Futyan & Vanlaer)

http://indico.cern.ch/conferenceDisplay.py?confId=12082

- LPC EGamma
  - still discussing both topics and try to “cluster” the effort around subset of things people are interested in
  - try to get most out of people who are not at CERN and can not spend 50% of their time there

Electrons and Photons

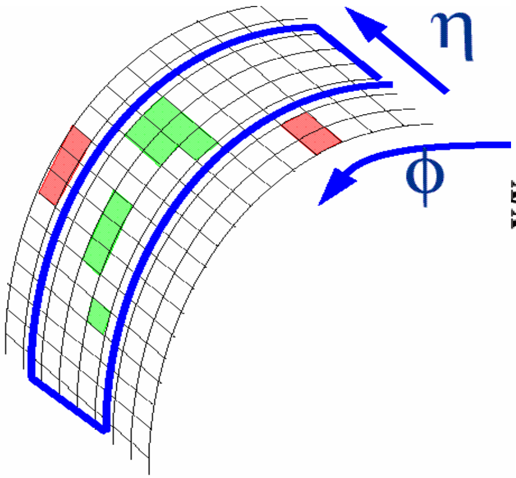
- Lead Tungstate crystals $\Delta\varphi \times \Delta\eta \sim 0.02 \times 0.02$
- Biggest challenge is the amount of material in front of the ECAL

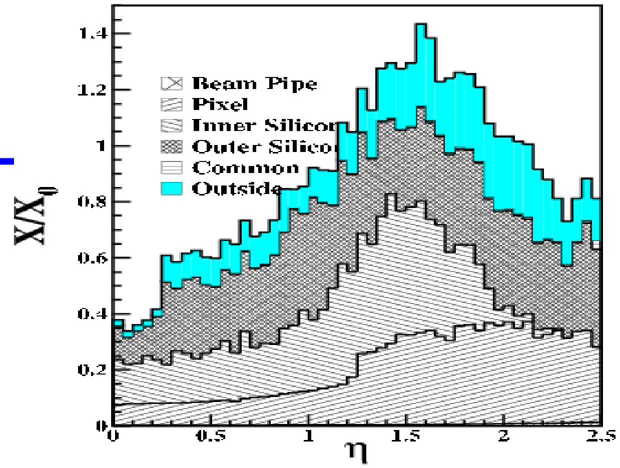
Cluster Reconstruction:

- find bumps in calorimeter
- cluster the bumps
- approximate window size $\Delta\varphi \times \Delta\eta \sim 0.8 \times 0.06$

Corrections:

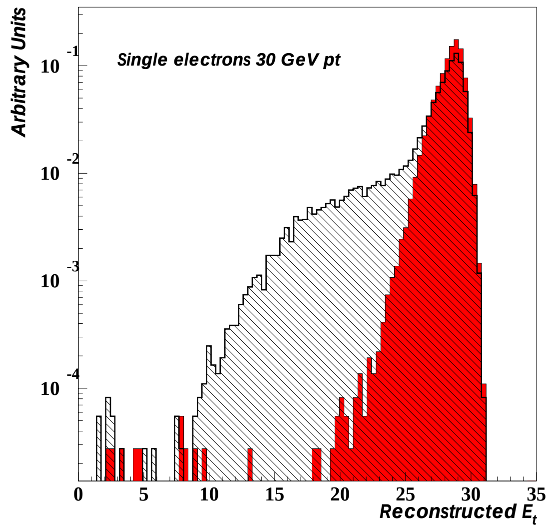
- containment, cracks, energy loss in the tracker material





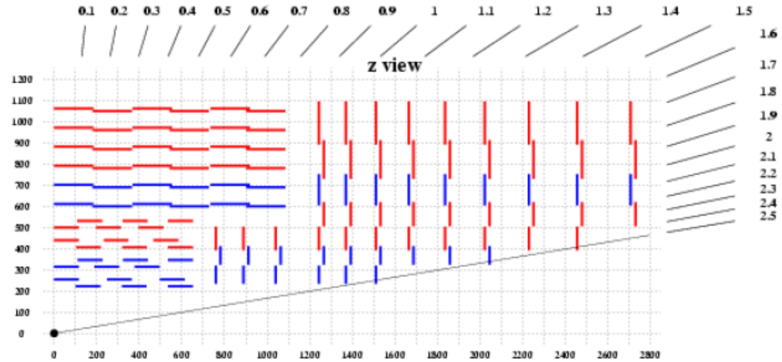
Electrons and photons propagate differently

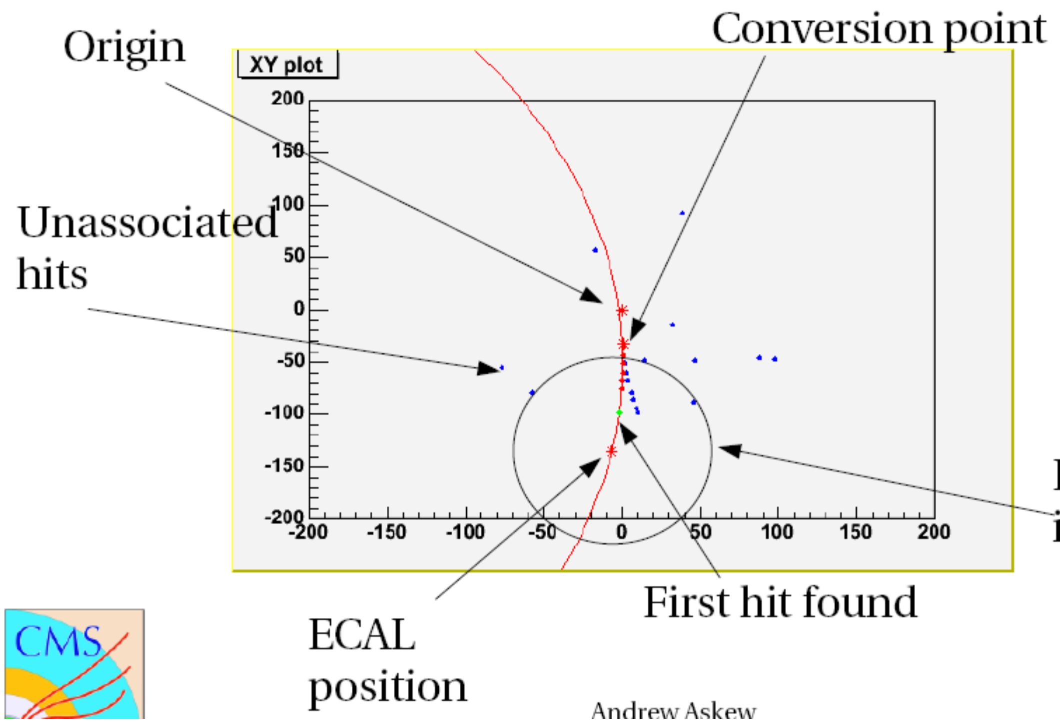
- electron continuously looses energy via Bremsstrahlung
- photons propagate intact until the first conversion
- Energy scales are different and depend on detector region (both rapidity and azimuth) and shower shape cuts

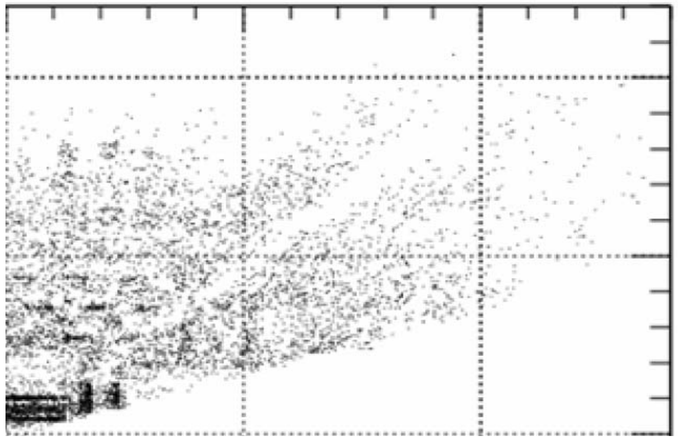


Tracker Material Description

- Method 1: photon conversions
  - gives spatial material distribution
  - Material at beam pipe is more dangerous than at ECAL face

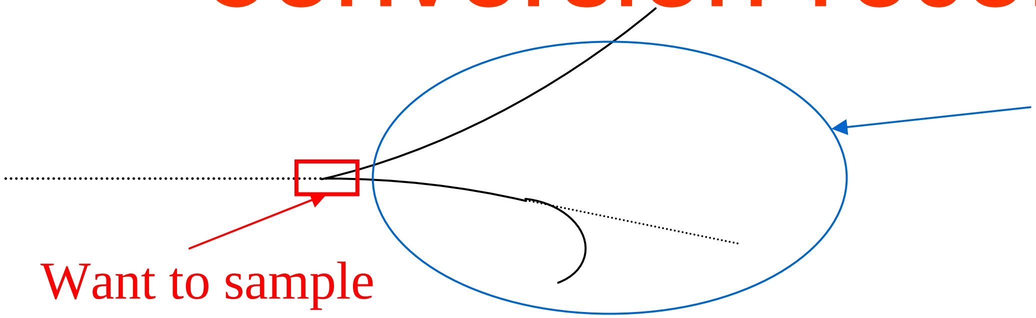






Andrew Askew 12

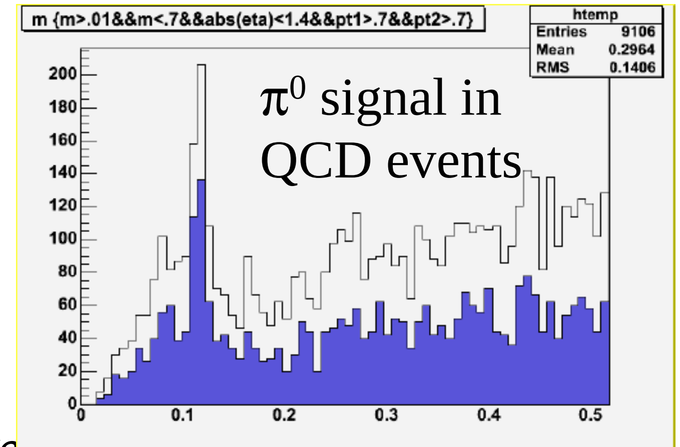
Conversion reconstruction



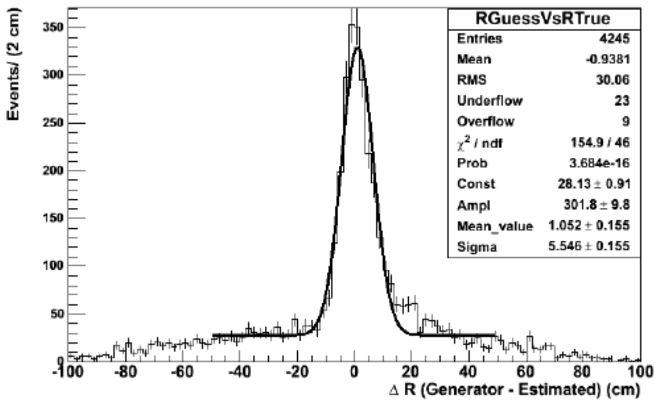
Want to sample material here

But the number of reconstructed conversions strongly depends on the amount of material here, too

- Very tough to get rid of biases
- Can reconstruct $\pi^0 \to \gamma\gamma \to \gamma ee$ with calorimeter only
  - If electrons from a photon do not brem "much", direction of original photons and conversion point can be reconstructed from two calorimeter clusters

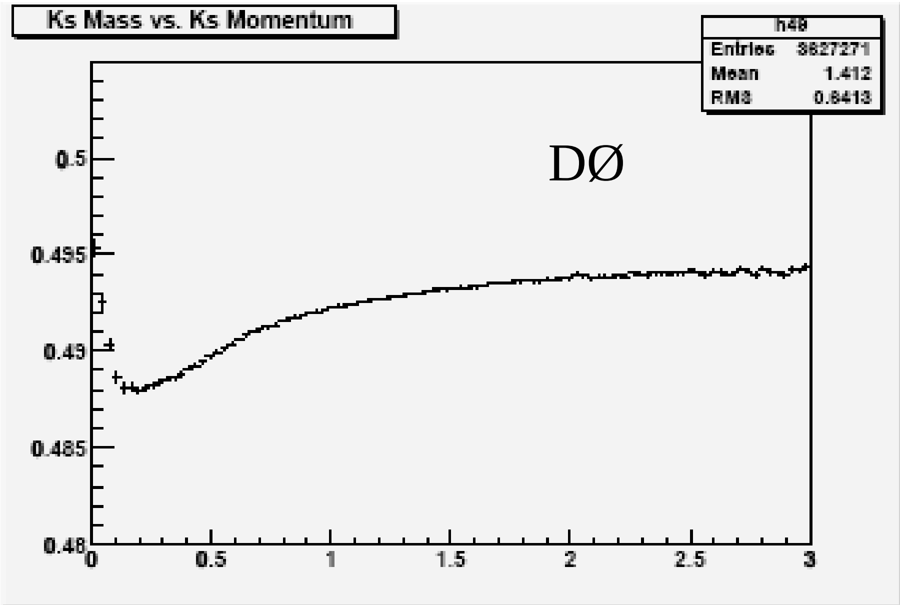


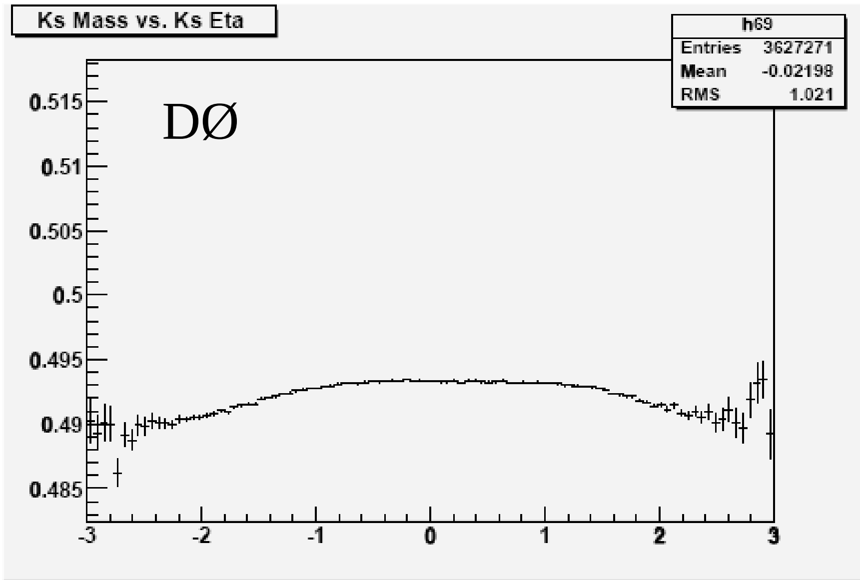
Radial resolution ~5 cm



Tracker Material Description

- Method 2: resonance masses
  - Tracks loose energy in material – mass peaks shift
  - dependence on rapidity, energy, decay radius (for K_S)
  - so far task not taken (but need to verify with Tracker DPG)

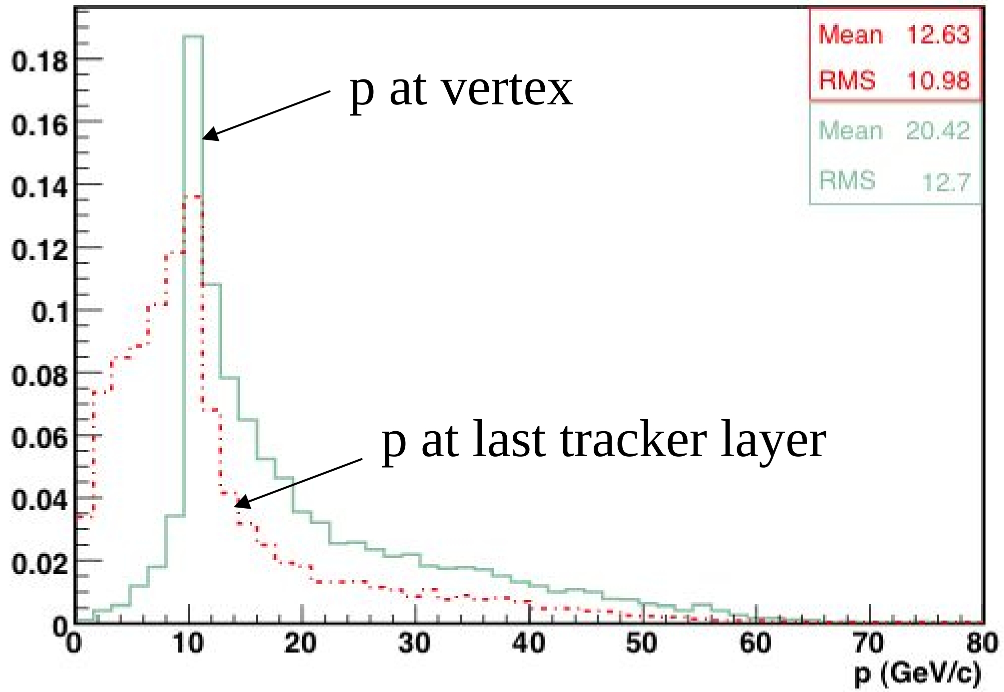




Tracker Material Description

- Method 3: measure how electrons loose energy
- GSF track fit allows for large curvature changes along a track
  - Energy loss due to brems can be measured (statistically...)
  - Promising method to determine total amount of material

C. Charlot, LLR



Algorithms for Start-up

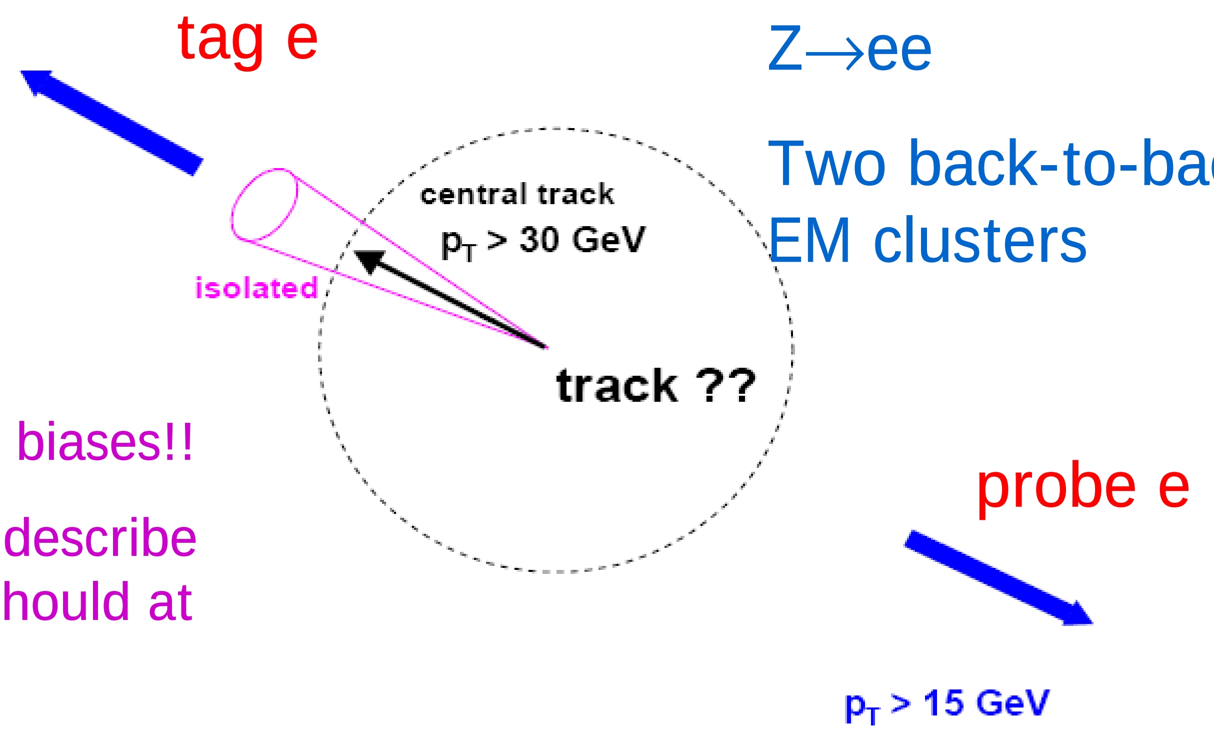
- To realize full LHC potential we need most sophisticated algorithms
- To commission detector we need first to find Z, W, Upsilon, etc
- Simple algorithms provide
  - Easier start-up
  - Redundancy and cross-check of sophisticated algorithms

- electron w/out pixels
  - “standard” algorithm finds pixel “stubs” and start tracking from them
  - Another algorithm w/out pixels is being developed. Will work when pixels are not there and will allow to check pixels efficiency when they are.
- simple fixed window clustering
  - “standard” algorithm has different number of crystals per cluster. A fixed window algorithm will insure us from many possible hardware malfunctions

- Particle ID: shower shapes, isolation, etc, etc

Efficiency from Data

- Tag and probe method: use Z decays
- Tightly identify one electron (and make sure that it gave trigger, too)
- The other electron is unbiased clean electron
  - use invariant mass distribution to count them



$Z \to ee$

Two back-to-back EM clusters

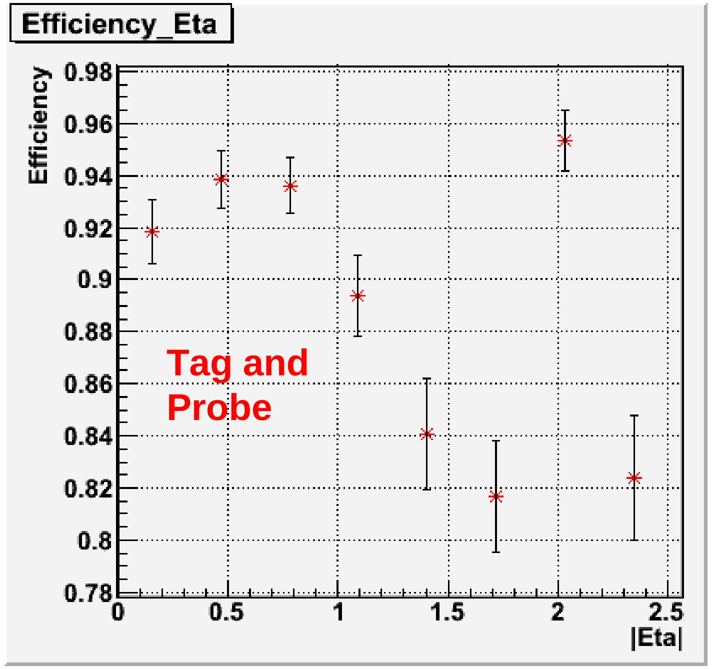
BUT: possible hidden biases!!

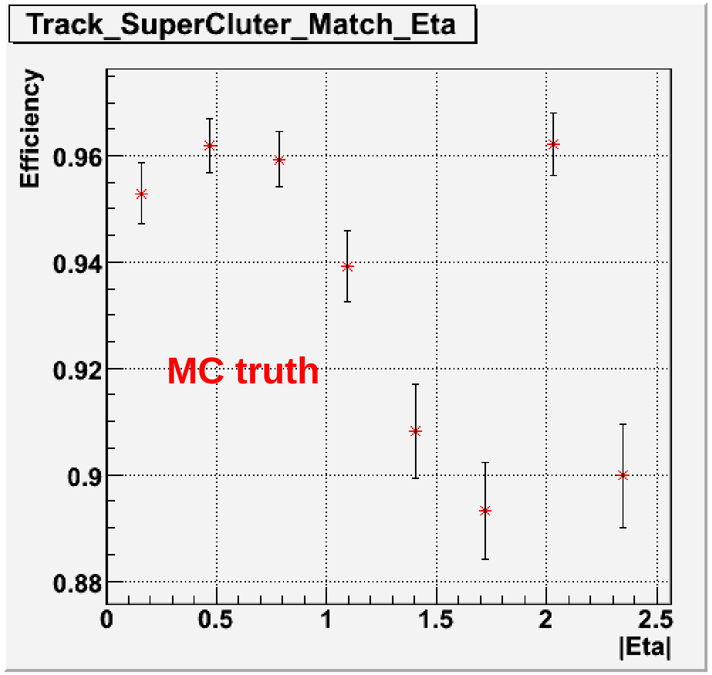
Do not expect MC to describe them exactly, but it should at least try...

Tag and Probe

+ The efficiencies from tag and probe method are compared to that from MC truth. To plot efficiencies from MC truth, take SCs that match to the MC electrons of Z decays and ask for their matching with tracks.

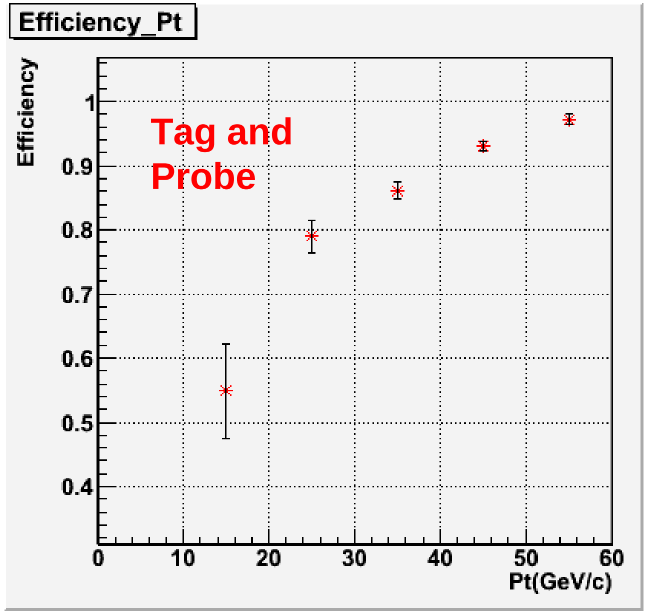
Duong Nguyen (Brown University)

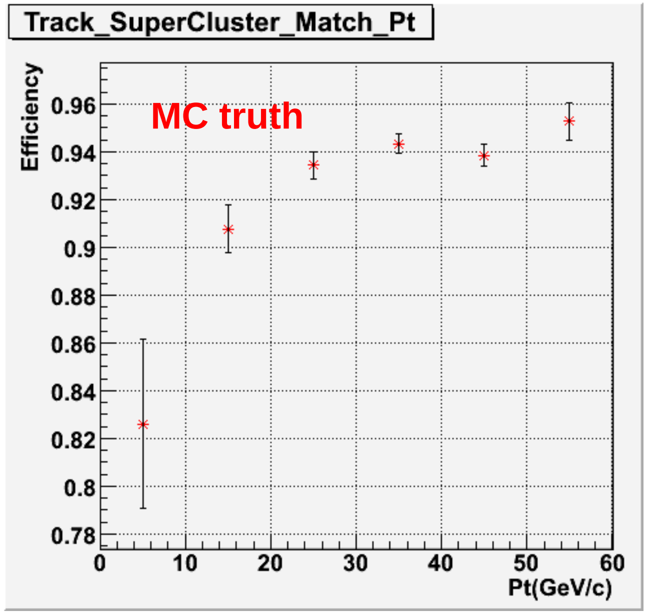




Tag and Probe (cont.)

Efficiency vs. transverse momentum





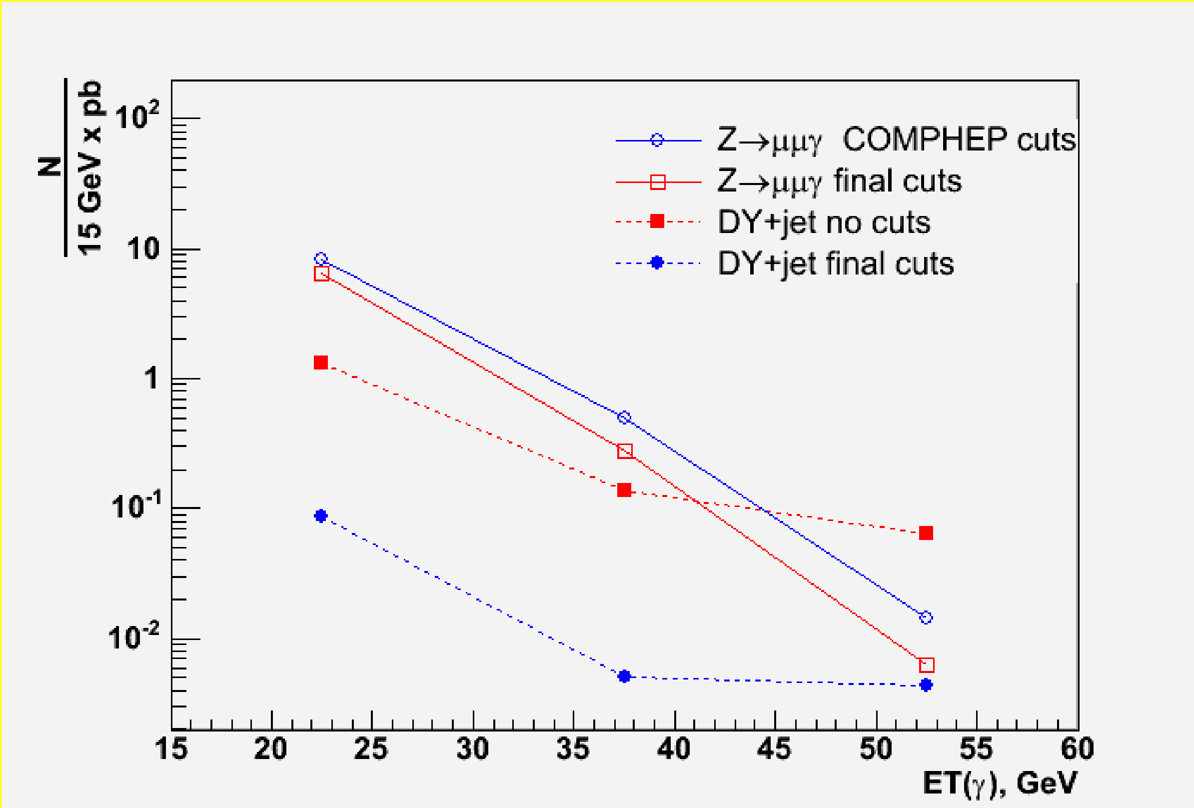
Cause of bias is under investigation

$Z \rightarrow \mu\mu\gamma$ as γ Calibration Source

- High cross-section of $Z\gamma$ reaction at LHC makes it possible to use the three-body mass peak to measure photon energy scale, efficiency and resolution
- The strategy:
  - Select two muons and very loose (and supposedly very efficient) EM cluster and count events in 3-body mass peak – N_1
  - Apply ID cuts and count events in the peak again – N_2
  - Efficiency = N_2/N_1
  - Measure energy scale from the position of the peak after the ID cuts
  - Measure resolution from the peak width
- The key is to get clean signal with very loose photon ID -> use kinematic cuts to suppress Z+jets
  - Need to cut out DY: $40 < m(\mu\mu) < 80$
  - dR(muon,photon) is small for $Z\gamma$: dR<0.8
  - $pT(\gamma) > 15$ GeV

Signal / Background

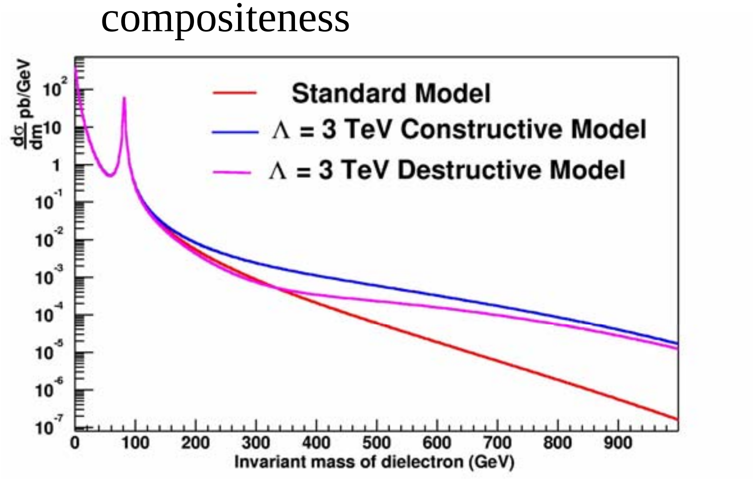
- Amazingly good S/B (~80) even before ID cuts!
  - PYTHIA probably underestimates Z+jets



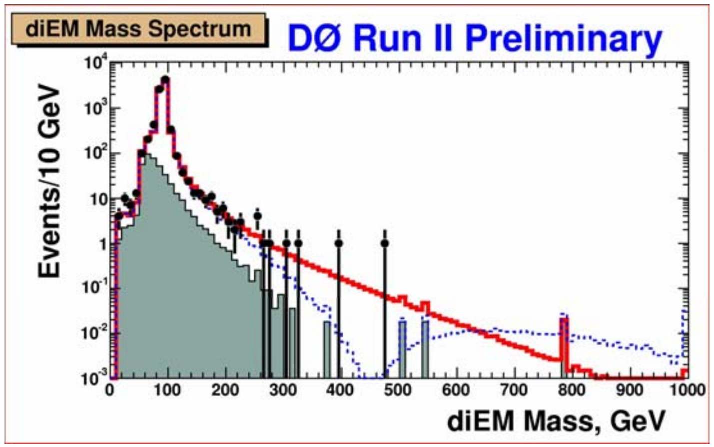
- Since S/B is so good, one should be able to study each discriminating variable for photon ID by itself and sort out the ones that are reproduced by the MC

High Energy Electrons

compositeness

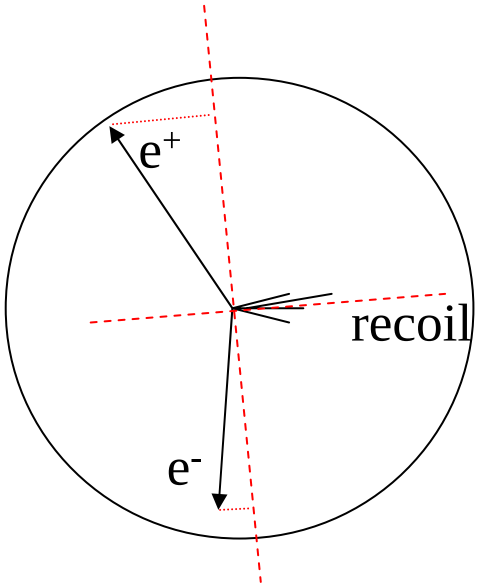


TeV^{-1} Extra Dimensions

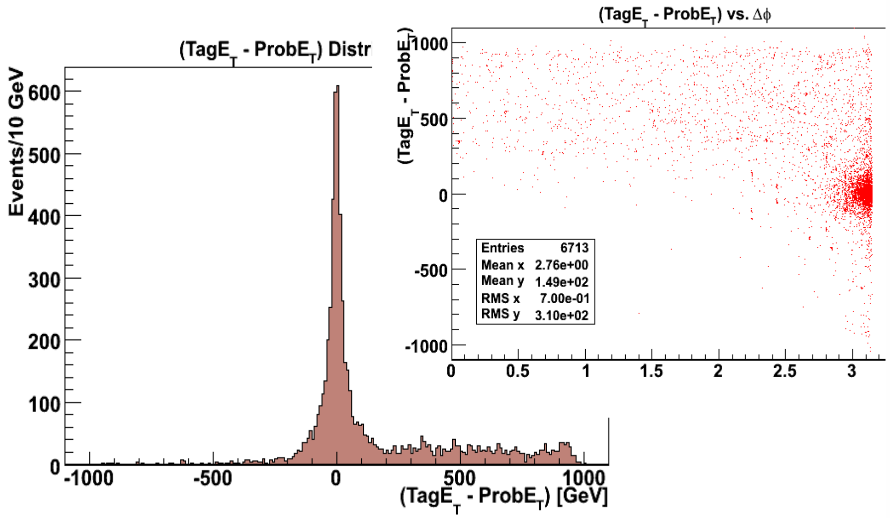


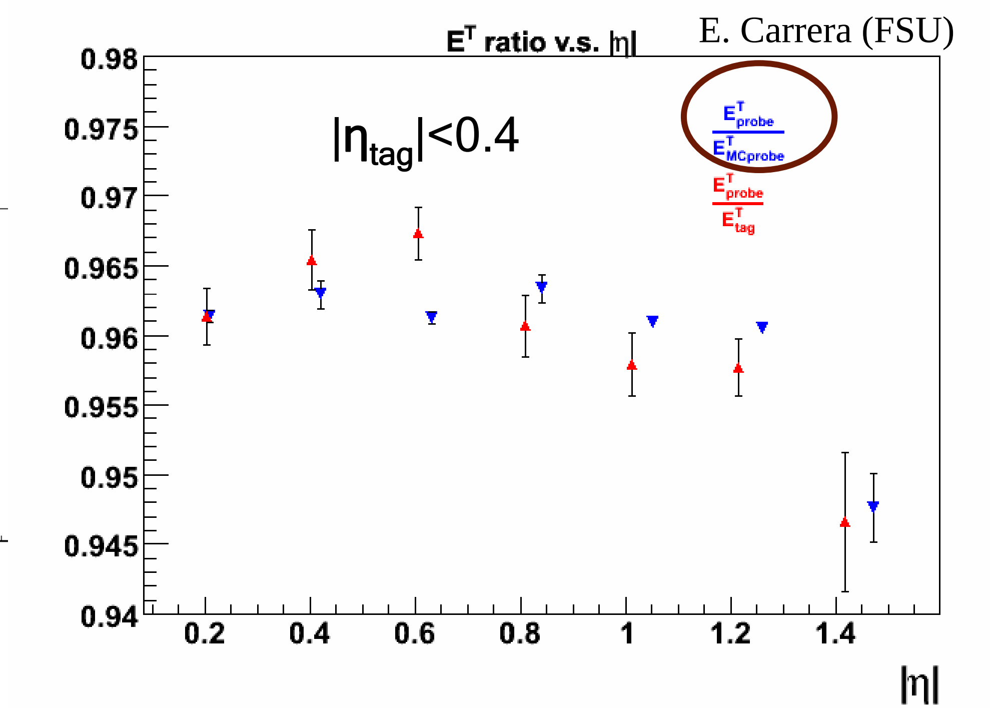
- New physics at DY tail may not come as a narrow peak...
- Systematic effects can fake a signal?
  - saturation
  - leakage
  - gain switches
- Would be nice to be able to check linearity at high energies with data

High Energy Electrons/Photons



- Balance electrons: energy varies with rapidity for same E_T, so one can relate higher to lower energy electrons
- So far checked if we can “measure” shower leakage effects





Summary

- Electrons and photons will lead to early physics
- A lot of preparatory work still to be done
- A large US effort
  - FSU, Notre Dame, Minnesota, Cornell, Brown, Virginia, Kansas State (may be more soon)

join the fun!